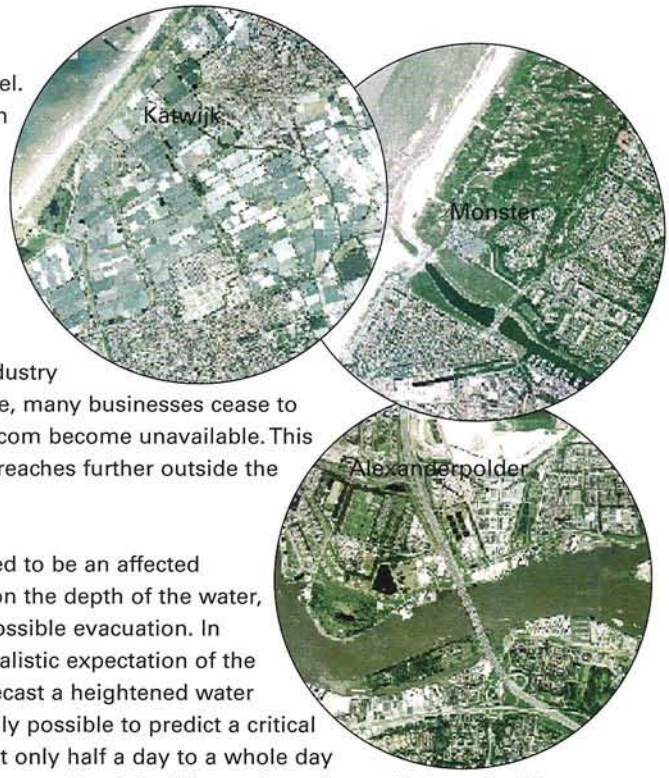
Ministerie van Verkeer en Waterstaat

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties

Breach at Katwijk, Monster and Alexanderpolder

Introduction

A large part of the Netherlands is located below sea level. Dunes and dikes protect us from floods originating from the sea, rivers and lakes. The level of protection which we strive to achieve in the Netherlands, is prescribed by law in the so-called "Flood defences Act". Nonetheless, a flood may still occur and result in great economic damages and a large number of affected individuals and casualties.



Following a flood, the material damages to housing, industry and infrastructure is significant. As a direct consequence, many businesses cease to operate and essential services like utilities, ICT and telecom become unavailable. This loss of service is not restricted to the flooded area, but reaches further outside the affected area.

Everyone within the 'threatened area' may be considered to be an affected individual. The number of casualties strongly depends on the depth of the water, the rate at which the water rises and the success of a possible evacuation. In order to start an evacuation, it is necessary to have a realistic expectation of the time and size of an imminent flood. It is possible to forecast a heightened water level, but this forecast is inherently uncertain. It is usually possible to predict a critical situation a few days in advance in the case of rivers, but only half a day to a whole day is available for the sea and lakes. The prediction of high water levels is different from the prediction of a dike breach. Predicting the occurrence of one or more breaches in a dike is more difficult and strongly dependent on the local situation and strength of the dike.

The actual time available for an evacuation of the Western part of the Netherlands, when the area is threatened by floods, is much shorter than the time required for a full evacuation. The required length of time for an evacuation is largely determined by the extent of the flood, the number of affected individuals, the capacity of the transport infrastructure, and the coordination of the evacuation and rescue operations. The available time for an evacuation may be increased by rapid decisions, through the application of traffic management and by adequate communication between authorities and civilians.

Three possible flooding scenarios have been developed:

1. A breach near the city of Rotterdam-Alexanderpolder along the river 'Maas'. The water level at the river is equal to the level of protection of dikes ('Flood defences Act'). A strongly urbanized area in South Holland will flood.
2. A multiple breach near the cities of Monster en Katwijk along the sea. The water level at sea is equal to the level of protection of dikes and dunes ('Flood defences Act'). The floodwater will spread through the canal system inside dikering 14 and threat Airport Schiphol.
3. A multiple breach near the cities of Monster en Katwijk (sea) and Rotterdam-Alexanderpolder (river). The water level at the sea and the river is a factor 100 more extreme than the level of protection of dikes ('Flood defences Act').

In this brochure the results of scenario **'Breach at Katwijk, Monster and Alexanderpolder'** are presented.

Flooding scenarios

A flooding scenario yields the progression of a flood. It gives insight into questions as: how large is the flooded area, how fast will the water spread and what is the water depth on a certain location? There are several different scenarios conceivable. Important components of a scenario are the locations of the breaches (in a real disaster there are often more than one) and the hydraulic load on the dam or dike. Further, the force of the flood wave depends strongly on the local situation behind the dikes and dunes.

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A design flood scenario (1/100.000 per year) depends on the criteria employed for it, like the extent, the damage, the demand for aid or the capacity of the emergency agencies. At the moment there is no consensus on an unambiguous design flood scenario. It does however seem to be sensible to take several flooding scenarios as a starting point for preparation, and build in flexibility for the demand on aid.

For the analysis of the scenarios a hydrodynamic and a damage/casualties model has been used. These models use data as water levels, wave heights at seas and in the river, land surface height, regional water courses, land use, number of inhabitants and the infrastructure within 'dikering Centraal-Holland' (Hoogwater Informatie Systeem instrumentarium). This 'dikering' (14) encompasses amongst others the cities of Rotterdam, Amsterdam and The Hague but also Airport Schiphol. The 'dikering' is situated in three provinces: South Holland, North Holland and Utrecht.

Description of a breach from the river dike and the sea dike

Load from the see and river

The flood is based on a situation 100 times more extreme than the protection level as described by law (in the before mentioned 'Flood defences Act') for 'Centraal Holland'. This means that the load of the river water and seawater on the dikes and dams is greater than the level of design. The high sea level is caused by storm at sea during spring tide. Furthermore there is a relatively high river discharge.

Assumed in this scenario is that the situation is so extreme that the 'Maeslantkering' in the Nieuwe Waterweg has failed. Without any obstruction the water can flow from sea into the river. This causes very high water levels in the delta region for example near Rotterdam and Dordrecht. At other places along the river other dike breaches are likely, these have however not been analysed.

Multiple breaches

In this extreme situation multiple breaches are likely, as occurred in New Orleans (2005), Hamburg (1962) and Zeeland (1953). In this scenario we consider three simultaneous breaches:

- Katwijk, at connection of the drainage system of 'Water board of Rijnland',
- Monster, in seawall just south of The Hague,
- Rotterdam-Alexanderpolder, breach in river dike just west of the Brienenoordbrug.

The above-mentioned breaches from sea and river have been analysed separately for a less extreme situation. For this a situation equal to the protection level as described in the 'Flood defences Act' was considered.

Extent of flooding

Ultimately an area of over 1200 square kilometre will be flooded. Within one day almost 900 square kilometres will be flooded. This area is much larger than the sum of the two separate scenarios as analysed for a less extreme situation.

Many dikes and dams along the drainage system inside dikering 14 also fail however it is difficult to predict the exact location. The river water and seawater will spread fast through the drainage system and the water level in this system cannot be controlled anymore. Dikes along the canal system fail on several locations. On these locations there will also be a flood.

The water depth in the flooded areas will vary and is strongly dependent on land surface height. There still are grounds that will not be flooded but they will be completely isolated. It appears that a large area of this 'dikering' can be flooded. For example, in this scenario larger areas of higher situated city centres like The Hague and Delft will also be flooded.

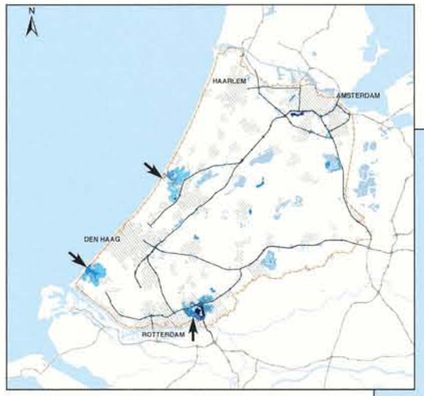
Schiphol

The dike along the 'Ringvaart van de Haarlemmermeer' (a large drainage canal) fails in this scenario. This means that Airport Schiphol will be flooded in about 12 hours after the start of the total flood event. In the other, less extreme, scenarios Airport Schiphol did not flood because of the smaller supply of water and the dikes and dams within the 'dikering' which did not fail.

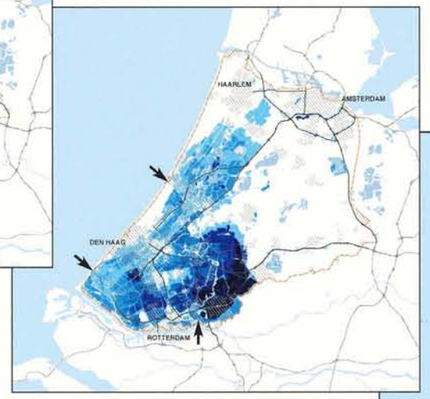
Damage

Based on the water depth and the land use, the damage of the flood is calculated. The total damage on residences, businesses and infrastructure and damage by businesses ceasing to operate is estimated at approximately € 100 billion. More than two third of this damage, € 66 billion, is already caused within one day.

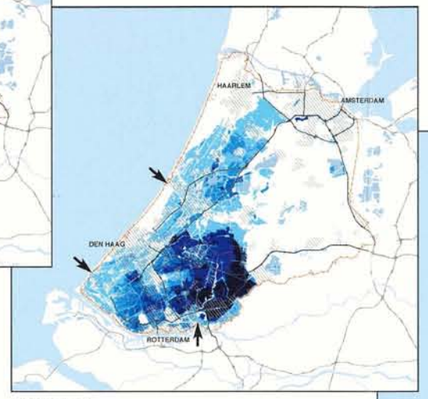
PROGRESSION OF FLOODING AFTER KATWIJK, MONSTER AND ALEXANDERPOLDER BREACH



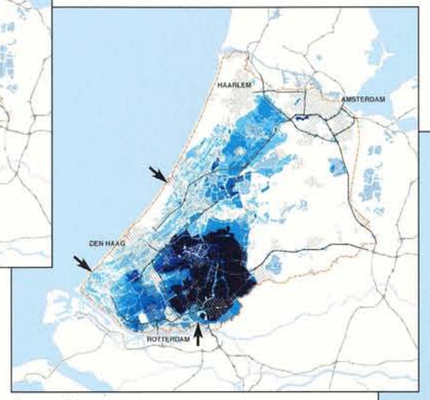
4 hours



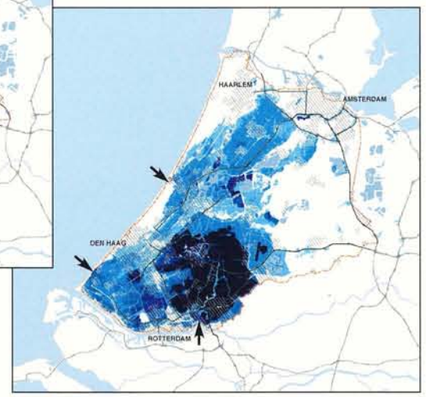
24 hours



48 hours



1 week



Maximum waterdepth

Time to flooding (first 24 hours)	
Road and municipal boundary	**Hours**
Katwijk, Westland, Rotterdam	1
Oegsgeest, Naaldwijk	2
A16, A20, A44, Wassenaar, Cappelle a/d IJssel	3
Berkel en Rodenrijs, Den Haag	6
Leiden	8
Delfland	9
Rijswijk	11
A12, Haarlemmermeer, Schiphol, Zoetermeer, Gouda, Voorburg	12
A4	14
A13, Vlaardingen	16
Pijnacker	17
Bloemendaal	18
Alphen a/d Rijn	24

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

water depth [m]
- no water
- < 1
- 1 – 2
- 2 – 3
- 3 – 4
- > 4

0 5 10 Kilometres

Affected individuals and casualties in flooded area

Affected individuals per municipality

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

Affected individuals per municipality
- no affected induviduals
- 1 – 100
- 100 – 1.000
- 1.000 – 10.000
- 10.000 – 100.000
- > 100.000

0 5 10 Kilometres

Casualties (evacuation and traffic management)

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

Casualties per community
- no casualties
- 1 – 10
- 10 – 100
- 100 – 1.000
- 1.000 – 10.000
- > 10.000

0 5 10 Kilometres

Damages in flooded area

Damages per municipality

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

Damages per community
- < 0,5 mln
- 0,5 – 5 mln
- 5 – 50 mln
- 50 – 500 mln
- 500 – 5.000 mln
- > 5.000 mln

0 5 10 Kilometres

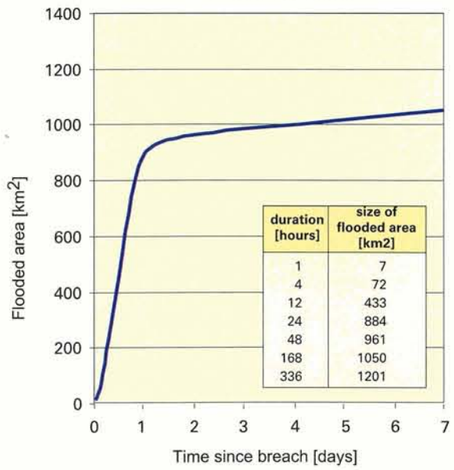
Damages per hectare

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

Damages per hectare
- no damage
- < 0,05 mln
- 0,05 – 0,5 mln
- 0,5 – 5 mln
- 5 – 50 mln
- > 50 mln

0 5 10 Kilometres

Extent of flooding



duration [hours]	size of flooded area [km2]
1	7
4	72
12	433
24	884
48	961
168	1050
336	1201

Key values				
duration [hours]	**damages [million euro]**	**number of affected individuals**	**number of casualties***	**number of casualties****
1	800	100,000	10	10
4	8,000	260,000	200	150
12	39,000	820,000	5,300	4,200
24	66,000	1,450,000	5,550	4,450
48	72,000	1,500,000	5,600	4,500
168	83,000	1,550,000	8,300	6,600
336	99,000	1,700,000	10,000	8,000

* without evacuation
** with preventive evacuation and traffic management

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Casualties

The total number of inhabitants in the flooded area is over 1,700,000 people The number of casualties will depend on the number of affected people in the flooded area, the water depth and the rate of increasing water depths. Particularly rapidly rising water levels can cause casualties.
The water depth as well as the rate at which it rises are much larger than that for the scenarios in which a situation equal to the protection level in the 'Flood defences Act' was considered.

Without any evacuation more than 10.000 casualties are estimated. With an evacuation that starts 15 hours before the beginning of the flood and by practising traffic management approximately 2.000 casualties can be prevented.

Evacuation and the decision to evacuate

The water level expected to cause the failure of the dike in this scenario can be predicted approximately 15 hours in advance. The expected water level is based on predictions of wind direction and speed, tidal fluctuations and river discharge.
The assumption is made that all inhabitants of the threatened area will be evacuated to outside the affected area. Furthermore, it is assumed that evacuation takes place from the place of residence and that existing infrastructure is used. No use has yet been made of local high grounds and shelters. A difference is made in evacuation with and without traffic management. The most important roads used during evacuation are the highways:

- A16 from Brienenoord in the direction of Breda,
- A12 in the direction of Utrecht,
- A9 in the direction of Alkmaar and Diemen,
- A10 in the direction of Amsterdam.

Without traffic management it will take in total over 10 days to evacuate the entire area; with traffic management this can be reduced to slightly more than 4 days.

In the available 15 hours tween the decision to evacuate and the predicted start of the flood approximately 15% of all people can be evacuated with efficient traffic management. Without this traffic management about 90,000 people less can be evacuated, as is illustrated in the graph and figure shown on the next page.

Lessons learned from the scenarios

The rate of spreading of the water and the final extent of the flooded area are strongly dependent on the location of the (multiple) breach(es) and on the water levels and wave heights at sea and in the river. It also appears that it is very unlikely that the whole 'dikering Centraal Holland' will be flooded. This is a recent notion, because even the Delta commission has assumed that the whole of Centraal-Holland will be flooded up to the border of the dikes. This assumption is based on the flood of 1953. Even in very extreme circumstances more than half of the 'dike-ring Centraal Holland' will not be flooded because of the limited supply of water, the relatively high position of the dunes along the coast, the relatively large extent of 'dikering 14' and the presence of other dikes and dams inside the 'dikering'. The extent however will be that large that virtually always borders of communities, water-boards, safety regions and sometimes even provinces are crossed.

However, there also appears to be preparation time for government as well as citizens, to act and prevent damage and casualties. This time consists of the prediction time of the critical water level and the time needed for the water to spread over the land.

In the present example for evacuation no difference is made in the phasing of evacuation streams; also no people are evacuated to 'safe havens' such as high buildings and higher situated grounds inside the flooded areas. Until today it has always been assumed that everyone, more or less at the same time, will be evacuated to outside the 'threatened area'. By making an area-specific evacuation plan more people can be brought to safety and potential casualties can be prevented. In this plan failure of utility services, ICT and telecom services will have to be taken into account, as will the availability of personnel, the preservation of the public order and relief.

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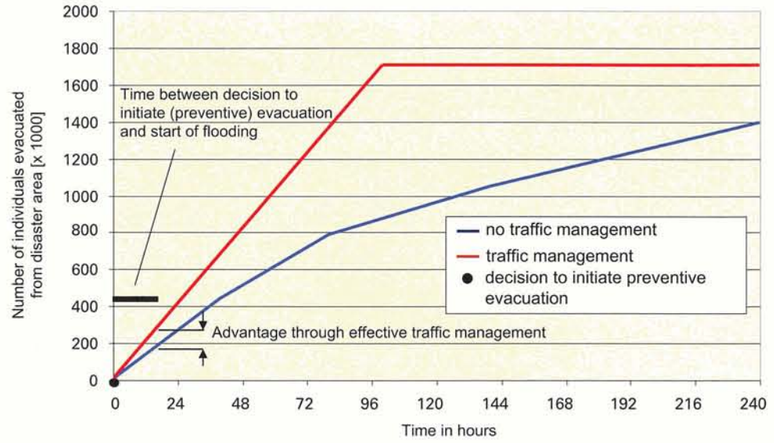
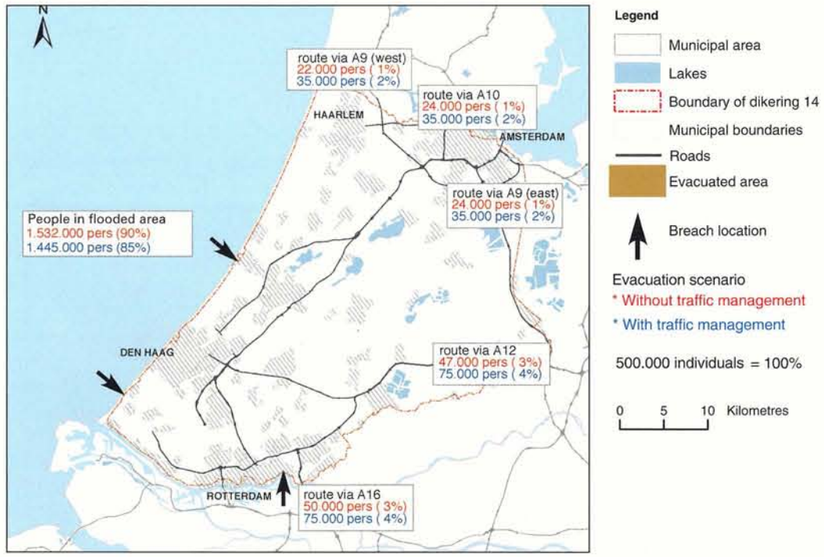
Progression of evacuation



Impact of trafficmanagement on success of evacuation



delay decision evacuation in hours	number of individuals in disaster area
0	1,445,000
1	1,462,000
6	1,547,000
12	1,649,000
Based on the 100 hours which are required for a total evacuation and a decision which was taken 15 hours prior to the evacuation	

Duration of road usage for evacuation	
No traffic management	With traffic management
A9 west 38 hours	A9 west 100 hours
A10 135 hours	A10 100 hours
A9 oost 40 hours	A9 oost 100 hours
A12 80 hours	A12 100 hours
A16 >240 hours	A16 100 hours
Maximum duration >240 hours	**Maximum duration 100 hours**

Information

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